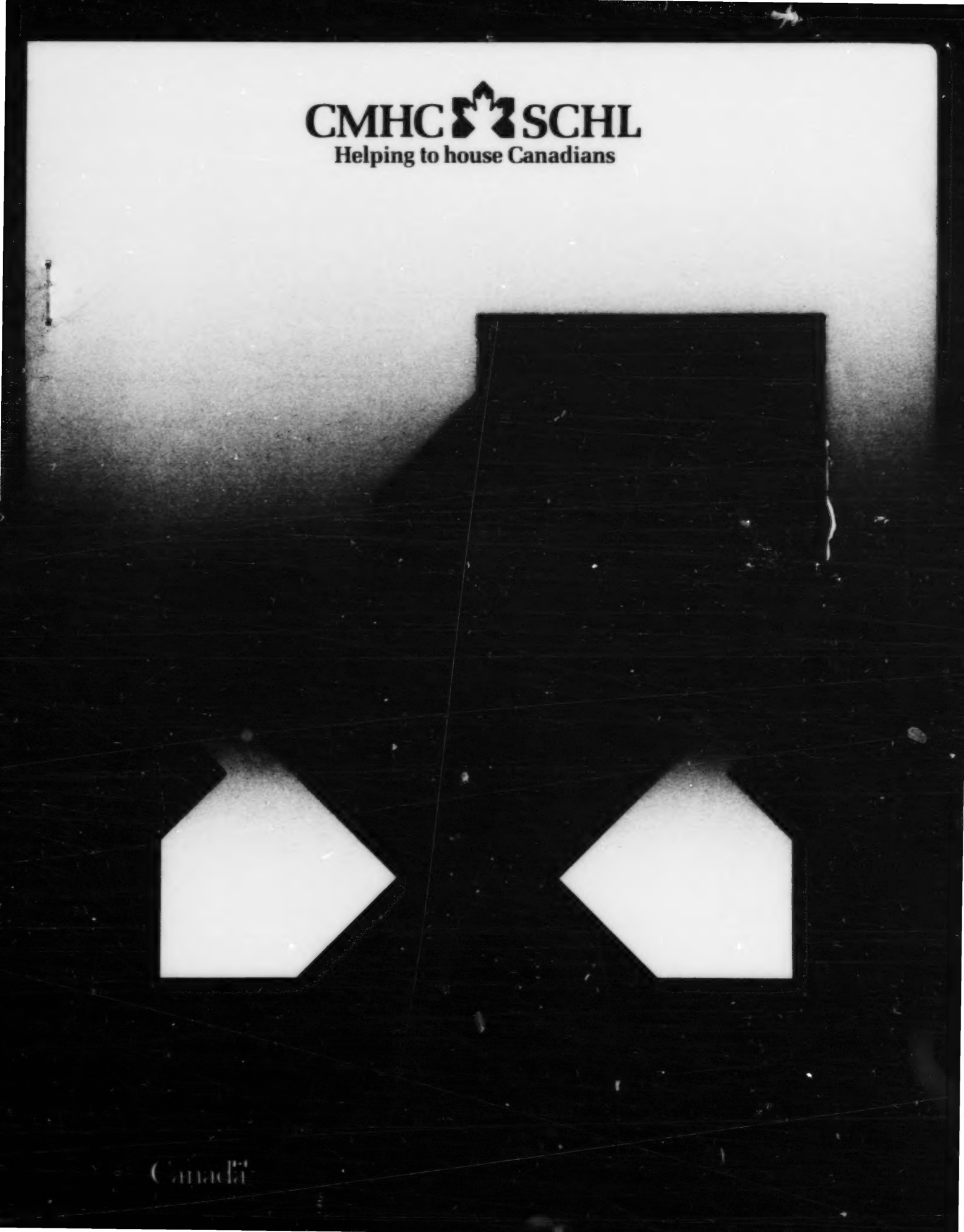
CMHC SCHL
Helping to house Canadians
Canada

91-06008/

STAINING OF JOINT COMPOUND ON DRYWALL

Prepared for:
Mr. Jacques Rousseau
Senior Project Manager
Canada Mortgage and Housing Corporation
682 Montreal Road
Ottawa, Ontario
K1A 0P7

Submitted by:
Sandringham Consultants
A member of the Sandringham Group Inc.
3017 St. Clair Avenue
Burlington, Ontario
L7N 3P5
Tel: (416) 332-7832
Fax: (416) 634-9095

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Prepared by: John L. Pugh

EDITORIAL

This report is phase 1 of the investigation into the cause of drywall discoloration problems in new houses. Its purpose is to outline the background, the facts and analytical information obtained from the sampling and testing program and to make interim suggestions for the Builder to adopt in order to minimize the effect of discoloration.

It is also intended that this report should form the framework for the recommendations in phase 2 of the investigation.

* * * * *

This CMHC project was undertaken by Sandringham Consultants with assistance from the Canadian Home Builders Association and the National Research Council.

OBJECTIVES

1. To determine the cause of the drywall discoloration problems reported form Alberta, British Columbia and Ontario.

2. To suggest potential solutions.

THE PROBLEMS

Over the years there have been many complaints of discoloration on gypsum wall finishes, some on plaster and, more recently, on drywall. In most cases these complaints were due to moisture-related conditions, biological in nature, and were easily remedied by sponging down with household bleaches.

At first report it was assumed, logically, that these new complaints of discoloration were also common moulds which could similarly be removed by bleaching. However, upon investigation this proved not to be the case, but rather a dark stain appearing only on the areas covered by joint compound. The nailspot areas as well as the actual wallboard joints were involved. This darkening effect was usually about four to five inches wide and stretched the complete length of the joint. It appeared usually on ceilings which has been texture sprayed. The stains seemed to be progressive with time but generally appeared to peak about five to six months after completion of the house. Occupancy of the residence can be a critical factor, with lifestyle playing an important role. However, one complaint was received after a new home, left vacant for several months, was occupied.

BACKGROUND

Due to the large number of potential claims in Alberta some privately sponsored preliminary work was done by the Alberta Research Council to try to establish the cause of the problem. Although the ARC did not have the equipment necessary to complete all the tests, they did examine thoroughly some samples taken in Edmonton and established that the stain was not a biological growth. They also conducted a limited literary search to determine available published information on drywall discoloration problems. The object of the search was to develop a perspective of the work already carried out on the subject.

In one case, a New Zealand scientist concluded that antioxidants in adhesives migrated through gypsum board when the board was glued to framing rather than nailed. This study contained some interesting chemical information but was not of any direct value when trying to solve the Canadian problem.

The ARC continues to offer assistance.

By July 1988 many questions were being asked. We visited, and took samples from the problem houses in Alberta and sent them immediately to NRC Ottawa for testing and appraisal. Some of the questions raised were:

BACKGROUND (cont'd)

1. Should it be assumed that the staining which occured was caused by an external contaminant; and if so, why was it not universal on all joints in the same room?

2. Why did one house develop the problem and not the one next door finished at the same time?

3. Did living conditions such as cooking, showers, laundry add to or cause the problem?

4. Did wall coverings, such as wallpaper, mask the staining?

5. Could certain products such as joint compound, paper tape, paint, or wallboard be eliminated from the investigation?

6. Why did the stain take several months to appear?

7. Why was the stain only on the joint coumpound?

8. Had the compound deteriorated under the stain; i.e., adhesion?

BACKGROUND (cont'd)

Some of the facts established from the sampling process were:

1. All of the houses in question had high efficiency gas furnaces with humidity controls.

2. All of the houses were "tight", with glass fibre insulation and good vapour/air barriers.

3. The problem was not confined to exterior wall or ceilings: it appeared in basements, first and second storeys.

4. Most complaints were related to textured ceilings.

5. Complaints were not restricted to recognized high humidity areas: bedrooms, living rooms, dens, etc. were also involved.

6. The stain was not peculiar to any one product or manufacturer.

7. Joint tape could be eliminated because the problem occured on screw heads where no tape was used.

8. The problem only appeared several months after completion of the house, and did not seem to get worse with further aging.

SUMMARY

One complaint went to conciliaiton in August 1987. The Builder had to rectify the complaint "in the manner he sees fit," without any substantiation of the cause.

Another early complaint was more closely examined and, "... Based on experience with similar types of problems, and in keeping with the observations that were made, it is suspected that the problem has been caused by high moisture content in the joint compound at the time of painting or slow drying of the taping job. ...it is apparent that the affected areas are only those over the joint coumpound. No indication of the involvement of the gypsum wallboard could be seen. The microscopy examination did not find any notable signs of surface mould or fungus growth, nor did it reveal any notable effloresence of material on the surface".

A third investigation resulted in a categorical statement that "Mildew was not the cause of the stain". Although the report later states "...it is not known precisely what are the causes of the problem..."

Inspection of another residence was reported as "The problem appears to be linked to the drywall coumpound used at the tape joints. This type of staining or discoloration sometimes occurs when the colours used in the paint

SUMMARY (cont'd)

are sensitive to alkali and the drying out process of the coumpound is slowed down due to lack of heat, etc. However, it is unlikely that the light grey colour contains any alkali-sensitive pigments and the white textured ceilings certainly should not. We suspect that the drying out of the drywall compound may have been prolonged due to inadequate heating during the taping and filing process. This could have resulted in mildew growth developing at the tape joints, etc."

In July 1988 all of the above opinions were, or could have been correct based on the then current information.

The NRC has since become more deeply involved and has issued several reports.

A background "State of the Study" report was given to the Technical Research Committee of the CHBA in October 1988. The testing program at NRC was still in the early stages with no conclusive results.

In the period from October 1988 to February 1989 inclusive testing at NRC produced an initial theory that the common plasticizer used in joint compounds was migrating to the surface and forming a sticky film. Outside

SUMMARY (cont'd)

contaminants would adhere to this film and cause a visual darkening. This theory has been neither proven nor disproven. This chemical plasticizer can also be found in paints and no firm relationship can be established between them when applied to a wall under job-site conditions.

We have been uncuccessful in trying to duplicate the problem in a laboratory.

It appeared that similar problems had been apparent in the U.S.A., consequently we visisted the research facility of a large U.S. gypsum manufacturer and discussed the problem. The following topics were touched upon:

1. Mercuric staining of zinc oxide from replacement of titanium oxide in paints with lithopone.

2. Staining studies in Japan where stains appeared at the joints of drywall through vinyl wallpaper.

3. The possibility that di-butyl-phthalate was involved.

4. The likelihood that the cause was either zinc or mercury related.

SUMMARY (cont'd)

5. The use of Abbot "Amcol 48 or 50".

6. Shadowing problems with lightweight joint coumpounds.

7. The use of various paints including primer-sealers.

8. Hydrogen sulfide sources in buildings.

9. Gas heated clothes dryers.

10. The use of diluted water-based paints.

11. The addition of soap to joint compound.

12. The "wicking" of ions to the surface.

13. A tentative solution for the Builder.

14. Correct heating during the taping process.

15. The sequence for investigating (testing) staining.

SUMMARY (cont'd)

16. The shortage of titanium oxide and its replacement with lithopone.

17. The replacement of phthalates in joint compounds.

18. Cobalt (in oil paint) reacting with hydrogen sulfide.

19. The use of preservatives in joint compounds and paints.

20. The use of flat latex as opposed to primer-sealers.

21. Special problems which occur with lightweight compounds.

22. Comparison of the condition of joints in garages as opposed to those inside houses.

23. The evaporation time for plasticizers.

The above emphasizes that while important knowledge has been obtained, considerable testing and appraising still remains to be done.

CONCLUSION

An interim report was given to the Technical Research Committee of the Canadian Home Builders Association in February 1989.

Because no finite cause had been established, the interim report was aimed at the problem from a Builder's point of view and the real question - "What can be done at this time to eliminate the problem?".

We would, therefore, reiterate our proposal made in February 1989:

1. Be sure there is good supervision on the jobsite particularly during the drywall taping, finishing and painting stages.

2. Be sure that the applicators use good building practices at all times; i.e., proper storage, etc.

3. Be sure that the compounds thoroughly dry between coats. Consult your manufacturer for proper drying times.

4. Be sure to provide proper heat during cold weather before, during and after compound application; i.e., consistent heating day and night.

CONCLUSION (cont'd)

5. Be sure to provide adequate ventilaiton to ensure proper drying.

6. Be sure that the finish coat of compound is throughly dry, then lightly sand with 150 grit sandpaper before painting.

7. Prime the finished surface, whether it is a ceiling to be textured or a flat surface to be painted, with a good quality latex or alkyd paint according to the manufacturer's instructions. This primer should have a high solids and a low PVC (pigment volume content). Check with your painter and paint supplier.

8. Allow the prime coat to thoroughly dry before final finishing.

RECOMMENDATIONS

We would strongly urge that a second phase of the investigation be initiated without delay, the framework of which should be to:

1. Resolve what substances occur at the stain.

2. Determine whether there are any physical differences between the paint film in stained and unstained areas.

3. Define what factors and mechanisms control the formation of the stain.

4. Ensure co-operation between the paint and compound manufacturers particularly regarding formulation or application instruction changes, if necessary.

Thus, the completed investigation would provide the basic information required to:

1. Determine the acceptable procedures for filling joints in drywall.

2. Determine the acceptable procedures for surface preparation in advance of paint and/or texture finishing.

RECOMMENDATIONS (cont'd)

The Institute for Research in Construction of the national Research Council Canada has proposed a detail research program to further address this issue. (Appendix A)

Findings to date suggest that this project should be considered in order to bring this project to a satisfactory conclusion to the home building industry.

APPENDIX A

DRYWALL STAINING: Causes and Means of Prevention

Proposal to

Canadian Home Builders Association

from

National Research Council Canada
Institute for Research in Construction

June 1989

DRYWALL STAINING: Causes and Means of Prevention

1. SUMMARY

A research program is proposed to understand the causes of drywall staining in some new houses and to suggest methods for avoiding the problem in the future. The research program will focus on two issues. Firstly, an expanded program of chemical analysis will be conducted to identify probable causes of the stain. Secondly, a program of laboratory simulation will be undertaken to attempt to duplicate the staining phenomenon under well-defined and well-controlled conditions.

The goal of the research will be to make recommendations to avoid or minimize the future occurrence of similar problems. These recommendations will be directed to material manufacturers and/or subcontract trades, as applicable.

2. BACKGROUND

The appearance of stains on newly constructed walls and ceilings has been a recurring problem in Canada. The problem is sporadic and may only affect a few units in a construction project. When such a problem arises the principal concern becomes how to remove or hide the stain so that the aesthetic characteristics of the building are not impaired. Resolution of the problem is usually achieved by trial-and-error remedial procedures.

Although staining occurs in only a small percentage of construction, the cost of restorative work is significant. Action that can be taken to reduce the frequency of occurrence of staining problems is obviously in the best interests of the industry. In order for industry to gain the knowledge to address this issue in a logical manner, research is necessary to develop a better understanding of the causes of the problem.

The most recently reported staining on a large scale was in homes in Alberta. The initial request to IRC for assistance with the current problem originated with the Alberta Research Council, and much of the work undertaken in this project will pertain specifically to that problem. However it is believed that the information generated from the study

will be of benefit to the construction industry in all parts of Canada.

3. OBJECTIVES OF THE PROJECT

There are two prime objectives in this research project:

1. To identify the chemical components in a finished wall or ceiling system which are responsible for the staining problem. Once the stain-causing material is identified, its source will be traced to provide a significant clue as to the origin of the problem.

2. To simulate construction conditions in the laboratory to duplicate the staining phenomenon in a controlled environment. This would indicate the combinations of factors which must coincide in order for a staining problem to arise.

This information will be used to design a standard test procedure to be used in the future for assessing the compatibility between construction materials and the suitability of specific construction practices before a construction project is started.

4. APPROACH

The programs of chemical analysis and laboratory simulation will be conducted simultaneously. Information gathered during the analytical phase will be incorporated into the laboratory simulation program as appropriate. Each of these aspects are discussed in detail in the ensuing sections.

4.1 Chemical analysis

Investigative work already performed at IRC and at the Alberta Research Council (ARC) did not conclusively identify the stain-causing species. This program is designed to overcome some of the difficulties identified by these previous efforts.

Firstly, an attempt will be made to obtain a concentrated sample of the material responsible for imparting the stained appearance. If this proves successful, it becomes much easier to identify the stain-causing species, and a greater degree of confidence can be placed in the accuracy of the analyses.

Secondly, it is of utmost importance that the collection of samples be performed according to strict guidelines. The probability for conclusively identifying the stain-causing species will depend largely on the availability of good reference samples.

The most promising avenues for obtaining meaningful information are the following:

* extraction of the stain-causing component(s) from a sample using pure solvents of varying polarity.

The UV-visible absorption spectra of the sample and reference solutions will be compared. The extracted solutions will be concentrated, purified and then analyzed using standard identification techniques such as mass spectrometry (MS), Fourier transform infrared spectroscopy (FTIR) and nuclear magnetic resonance (NMR).

* FTIR spectroscopy of surface scrapings from the stained wall or ceiling section.

This technique will be applied to analyze and compare scrapings from stained and unstained areas. The most meaningful information is expected to result by subtracting the spectrum of the unstained specimen from the spectrum of the stained specimen. This difference spectrum should be largely attributable to the stain-causing species. Identification of the stain-causing species will proceed by analyzing specimens of known composition and searching reference libraries.

4.1.1 Collection of samples

An essential element to the successful identification of the stain-causing component is to obtain proper samples. The following samples are to be collected:

* sections of stained wall or ceiling, including joints. It is estimated that the size of each section should be about three feet wide, centred on the joint, by four feet long.

* sections of unstained wall or ceiling, including joints, from the same houses. In cases where this is not possible, the next best alternative is to obtain unstained samples from houses constructed by the same contractors during the same time periods.

* samples of building materials as representative as possible of those which were used in the joint construction, i.e., wood stud, drywall, drywall tape, drywall compound, stipple, primer, paint. These samples will be used as reference materials to trace the origin of the stain-causing material(s).

Stained specimens will be obtained from three different houses, preferably from different geographical locations. A representative from IRC will direct the sampling operation. Arrangements to restore sampled houses to original appearance are not included in this proposal. All available construction records for the sampled houses will be requested. The types of information sought will include: period of construction, subcontractors involved, completion dates of subcontract tasks and types of construction materials used.

4.2 Laboratory simulation of staining

A laboratory investigation will be performed to attempt to identify combinations of parameters which facilitate staining. Initially a broad-based screening study will be undertaken to determine which variables exert a significant effect on the staining process. To increase the chances for this screening study to succeed it is important to include all of the factors which could reasonably be expected to influence the staining process. Factors which will be considered can be grouped into the following categories: environmental, material and workmanship.

Laboratory specimens will be prepared by predetermined variation of each of these factors. The specimens will be placed in controlled atmosphere environments and periodically monitored for signs of discolouration. Specimens which become stained will be chemically analyzed to determine the degree of similarity between the laboratory stains and the field stains.

The following variables have been identified as possible contributors to the staining problem, and thus will form the basis for the screening study. If the client is aware of

other potentially important variables, the list will be modified accordingly.

4.2.1 Environmental factors

* ambient temperature
* relative humidity
* ultraviolet exposure
* contaminants in air (this will be addressed only if the analytical work indicates the problem is due to external contamination).

4.2.2 Material factors

* type of 2x4 lumber
* type of drywall
* type of drywall fasteners
* type of drywall tape
* type of drywall compound
* composition of added water
* type of stipple
* type of primer
* type of thinner
* type of paint

4.2.3 Workmanship factors

* moisture content of 2x4 lumber
* priming of wood studs
* drying time of wood primer

(It is recognized that priming the wood represents a departure from normal construction practice, but these factors have been included to determine if migration of lignin from the wood is a factor.)

* method of fastening drywall to studs
* method of tape application
* method of drywall compound application
* number of drywall compound applications
* drying time of drywall compound
* method of surface finishing of drywall compound
* use of special tooling liquids
* priming of drywall and drywall compound
* drying time of primer
* method of stipple application
* drying time of stipple
* method of paint application
* drying time between paint coats
* special finishing or drying techniques
* metal composition of tools and equipment.

5. DELIVERABLES

A status report will be delivered nine months after the start of the project. A final report will be delivered eighteen months after the start of the project. A seminar will be presented at a mutually convenient time, after acceptance of the final report.

Note: This timing is predicated on the assumption that the staining, if any, will become evident within twelve months after preparation of the laboratory specimens. In the event that the client wishes to have the study extended for a longer time period, the milestone dates will be changed accordingly.

6. TASKS

Task 1: Field visit and collection of samples

Task 2: Chemical analysis of collected samples

Task 3: Preparation of laboratory simulation specimens

Task 4: Monitoring of laboratory specimens

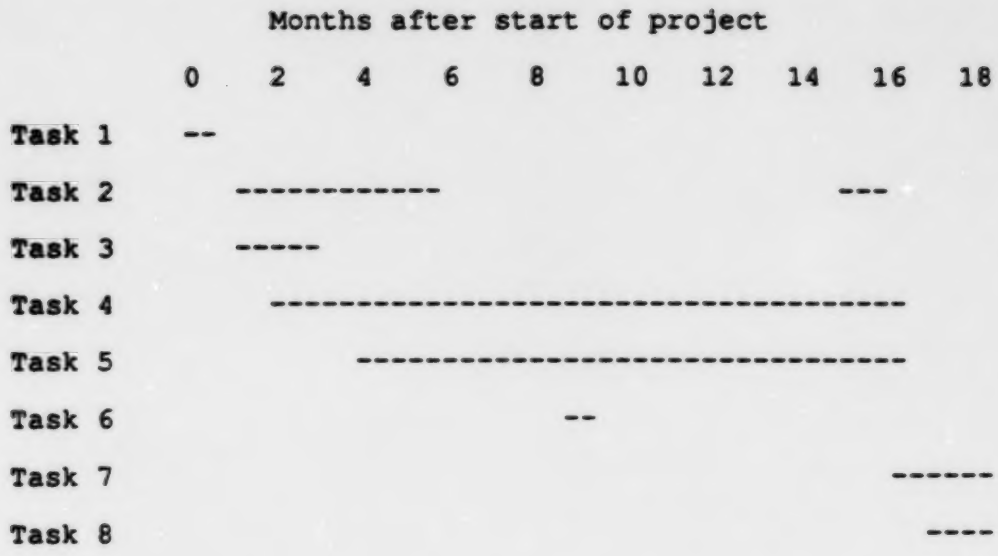
Task 5: Analysis of data

Task 6: Preparation of interim report

Task 7: Preparation of final report

Task 8: Preparation and presentation of seminar.

7. SCHEDULE


Months after start of project
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Task 1
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Task 6
Task 7
Task 8

8. PROJECT PERSONNEL

Dr. John Margeson, IRC/Materials Section, will be the Project Manager for the project. In this capacity, he will be responsible for the overall progress of the investigation, preparation of the interim and final reports and presentation of the seminar. He will be directly involved in the design and conduct of the laboratory simulation program.

Dr. Ralph Paroli, IRC/Materials Section, will be directly involved in the design and conduct of the FTIR portion of the chemical characterization program. He will assist in the monitoring of the laboratory simulation program, analysis of data and preparation of reports.

Dr. Ken Falk, IRC/Fire Research Section, will perform the extraction and characterization portion of the analytical program.

Mr. Noel Mailvaganam, IRC/Materials Section, will be directly involved in an advisory capacity to draw upon his experiences in related areas in private industry.

Mr. Cliff Shirtliffe, IRC/Building Performance Section, will assist in an advisory capacity to ensure there is continuity between the completed preliminary investigation and this project.

9. COST

The cost of performing this work is estimated to be $117,000.